

CLAIMS

[1] A rare-earth magnet comprising a magnet body containing a rare-earth element, and a protective layer formed on a surface of the magnet body;

5 the protective layer having a first layer covering the magnet body and containing a rare-earth element, and a second layer covering the first layer and containing substantially no rare-earth element.

[2] A rare-earth magnet according to claim 1, wherein the protective layer is formed by heat-treating the magnet body in an oxidizing atmosphere containing an oxidizing gas while adjusting at least one condition of a partial pressure of the oxidizing gas, a treatment temperature, and a treatment time such as to have the first layer covering the magnet body and containing a rare-earth element, and the second layer covering the first layer and containing substantially no rare-earth element.

[3] A rare-earth magnet comprising a magnet body containing a rare-earth element, and a protective layer formed on a surface of the magnet body;

20 the protective layer having a first layer covering the magnet body and containing a rare-earth element, and a second layer covering the first layer and containing a rare-earth element by an amount smaller than that in the first layer.

[4] A rare-earth magnet according to claim 3, wherein the protective layer is formed by heat-treating the magnet body in an oxidizing atmosphere containing an oxidizing gas while adjusting at least one condition of a partial pressure of the oxidizing gas, a treatment

temperature, and a treatment time such as to have the first layer covering the magnet body and containing a rare-earth element, and the second layer covering the first layer and containing a rare-earth element by an amount smaller than that in the first layer.

5 [5] A rare-earth magnet according to one of claims 1 to 4, wherein the protective layer contains oxygen and an element derived from the magnet body.

[6] A rare-earth magnet according to one of claims 1 to 5, wherein the magnet body contains a rare-earth element and a transition element
10 other than the rare-earth element;

wherein the first layer contains the rare-earth element, the transition element, and oxygen; and

wherein the second layer contains the transition element and oxygen.

15 [7] A rare-earth magnet according to claim 6, wherein the rare-earth element in the first layer, the transition element in the first layer, and the transition element in the second layer are elements derived from the magnet body.

[8] A rare-earth magnet according to claim 6, wherein the rare-earth
20 element in the first layer, the transition element in the first layer, and the transition element in the second layer are elements constructing a main phase of the magnet body.

[9] A rare-earth magnet according to one of claims 1 to 8, wherein the rare-earth element is neodymium.

25 [10] A rare-earth magnet according to one of claims 1 to 9, wherein the first and second layers have a total thickness of 0.1 to 20 μm .

[11] A rare-earth magnet comprising a magnet body containing a rare-earth element, and a protective layer formed on a surface of the magnet body;

the protective layer having an inner protective layer containing a rare-earth element and/or a transition element and oxygen, and an outer protective layer made of a constituent material different from that of the inner protective layer.

[12] A rare-earth magnet according to claim 11, wherein the inner protective layer has a first layer covering the magnet body and containing a rare-earth element, and a second layer covering the first layer and containing substantially no rare-earth element.

[13] A rare-earth magnet according to claim 11, wherein the inner protective layer has a first layer covering the magnet body and containing a rare-earth element, and a second layer covering the first layer and containing a rare-earth element by an amount smaller than that in the first layer.

[14] A rare-earth magnet according to claim 12 or 13, wherein the magnet body contains a rare-earth element and a transition element other than the rare-earth element;

wherein the first layer contains the rare-earth element, the transition element, and oxygen; and

wherein the second layer contains the transition element and oxygen.

[15] A rare-earth magnet according to claim 14, wherein the rare-earth element in the first layer, the transition element in the first layer, and the transition element in the second layer are elements derived from

the magnet body.

[16] A rare-earth magnet according to claim 14, wherein the rare-earth element in the first layer, the transition element in the first layer, and the transition element in the second layer are elements constructing a main phase of the magnet body.

[17] A rare-earth magnet according to one of claims 11 to 16, wherein the outer protective layer is an oxide layer having a composition different from that of the inner protective layer.

[18] A rare-earth magnet according to claim 17, wherein the oxide layer contains a metal element different from that contained in the inner protective layer.

[19] A rare-earth magnet according to claim 17 or 18, wherein the oxide layer is an amorphous layer.

[20] A rare-earth magnet according to one of claims 17 to 19, wherein the oxide layer has a layer made of a p-type oxide semiconductor, and a layer made of an n-type oxide semiconductor formed on the outer side thereof.

[21] A rare-earth magnet according to one of claims 17 to 20, wherein the outer protective layer is an oxide layer containing an oxide of at least one species of element selected from the group consisting of Al, Ta, Zr, Hf, Nb, P, Si, Ti, Mg, Cr, Ni, Ba, Mo, V, W, Zn, Sr, Bi, B, Ca, Ga, Ge, La, Pb, In, and Mn.

[22] A rare-earth magnet according to one of claims 17 to 21, wherein the oxide layer contains an oxide of Mo or W.

[23] A rare-earth magnet according to one of claims 11 to 16, wherein the outer protecting layer is a resin layer containing a resin.

[24] A rare-earth magnet according to claim 23, wherein the resin is a thermosetting resin.

[25] A rare-earth magnet according to claim 23 or 24, wherein the resin is at least one species of resin selected from the group consisting of phenol, epoxy, and melamine resins.

[26] A rare-earth magnet according to one of claims 11 to 16, wherein the outer protective layer is a metal salt layer.

[27] A rare-earth magnet according to claim 26, wherein the metal salt layer contains at least one species of element selected from the group consisting of Cr, Ce, Mo, W, Mn, Mg, Zn, Si, Zr, V, Ti, and Fe and at least one species of element selected from the group consisting of P, O, C, and S.

[28] A rare-earth magnet according to claim 26 or 27, wherein the metal salt layer contains at least one species of element selected from the group consisting of Mo, Ce, Mg, Zr, Mn, and W and at least one species of element selected from the group consisting of P, O, C, and S.

[29] A rare-earth magnet according to one of claims 11 to 16, wherein the outer protective layer contains an organic-inorganic hybrid compound having a structural unit made of an organic polymer and a structural unit made of an inorganic polymer, the structural units having a chemical bond therebetween.

[30] A rare-earth magnet according to claim 29, wherein the organic-inorganic hybrid compound is a compound having a covalent bond combining the structural unit made of the organic polymer and the structural unit made of the inorganic polymer together.

[31] A rare-earth magnet according to claim 29, wherein the

organic-inorganic hybrid compound is a compound having a hydrogen bond combining the structural unit made of the organic polymer and the structural unit made of the inorganic polymer together.

5 [32] A rare-earth magnet according to claim 29, wherein the organic-inorganic hybrid compound is a compound having the structural unit made of the organic polymer including an aromatic ring and the structural unit made of the inorganic polymer including an aromatic ring, the structural units being combined together by an interaction between the aromatic rings.

10 [33] A rare-earth magnet according to one of claims 11 to 32, wherein the outer protective layer further contains an inorganic additive.

[34] A method of manufacturing a rare-earth magnet by forming a protective layer on a surface of a magnet body containing a rare-earth element;

15 the method comprising a protective layer forming step of heat-treating the magnet body so as to form a protective layer having a first layer covering the magnet body and containing a rare-earth element and a second layer covering the first layer and containing substantially no rare-earth element.

20 [35] A method of manufacturing a rare-earth magnet by forming a protective layer on a surface of a magnet body containing a rare-earth element;

25 the method comprising a protective layer forming step of heat-treating the magnet body so as to form a protective layer having a first layer covering the magnet body and containing a rare-earth element and a second layer covering the first layer and containing a rare-earth

element by an amount smaller than that in the first layer.

[36] A method of manufacturing a rare-earth magnet according to claim 34 or 35, wherein the magnet body is heat-treated in the protective layer forming step in an oxidizing atmosphere containing an oxidizing gas while adjusting at least one condition of a partial pressure of the oxidizing gas, a treatment temperature, and a treatment time such that the protective layer has the first layer and the second layer.

[37] A method of manufacturing a rare-earth magnet according to one of claims 34 to 36, further comprising a pickling step of pickling the magnet body prior to the heat treatment.

[38] A method of manufacturing a rare-earth magnet according to one of claims 34 to 37, wherein the oxidizing atmosphere is a steam atmosphere having a steam partial pressure of 10 to 2000 hPa.

[39] A method of manufacturing a rare-earth magnet according to one of claims 34 to 38, wherein the treatment time is 1 min to 24 hr.

[40] A method of manufacturing a rare-earth magnet by forming a protective layer on a surface of a magnet body containing a rare-earth element;

the method comprising:

an inner protective layer forming step of heat-treating the magnet body so as to form an inner protective layer covering the magnet body and containing a rare-earth element and/or a transition element and oxygen; and

an outer protective layer forming step of forming an outer protective layer made of a constituent material different from that of the inner protective layer on a surface of the inner protective layer.

[41] A method of manufacturing a rare-earth magnet according to claim 40, wherein, in the outer protective layer forming step, the magnet body is heat-treated so as to form the inner protective layer having a first layer covering the magnet body and containing a rare-earth element and a second layer covering the first layer and containing substantially no rare-earth element.

[42] A method of manufacturing a rare-earth magnet according to claim 40, wherein, in the outer protective layer forming step, the magnet body is heat-treated so as to form the inner protective layer having a first layer covering the magnet body and containing a rare-earth element and a second layer covering the first layer and containing a rare-earth element by an amount smaller than that in the first layer.

[43] A method of manufacturing a rare-earth magnet according to claim 41 or 42, wherein, in the outer protective layer forming step, the magnet body is heat-treated in an oxidizing atmosphere containing an oxidizing gas while adjusting at least one condition of a partial pressure of the oxidizing gas, a treatment temperature, and a treatment time such that the protective layer has the first layer and the second layer.

[44] A method of manufacturing a rare-earth magnet according to one of claims 40 to 43, wherein, in the outer protective layer forming step, the outer protective layer made of an oxide layer having a composition different from the inner protective layer is formed on the surface of the inner protective layer.

[45] A method of manufacturing a rare-earth magnet according to one of claims 40 to 43, wherein, in the outer protective layer forming step, a resin layer forming coating liquid containing a resin is applied

onto the surface of the inner protective layer and dried so as to form the outer protective layer made of a resin layer.

[46] A method of manufacturing a rare-earth magnet according to claim 45, wherein the resin is at least one species of resin selected from the group consisting of phenol, epoxy, and melamine resins

[47] A method of manufacturing a rare-earth magnet according to one of claims 40 to 43, wherein, in the outer protective layer forming step, the magnet body after the inner protective layer forming step is subjected to chemical conversion treatment so as to form the outer protective layer made of a metal salt layer containing a metal salt on the surface of the inner protective layer.

[48] A method of manufacturing a rare-earth magnet according to one of claims 40 to 43, wherein, in the outer protective layer forming step, the outer protective layer made of a layer containing an organic-inorganic hybrid compound having a structural unit made of an organic polymer and a structural unit made of an inorganic polymer is formed on the surface of the inner protective layer.

[49] A method of manufacturing a rare-earth magnet by heat-treating a magnet body containing a rare-earth element so as to form a protective layer on a surface of the magnet body;

the method comprising:

a pickling step of pickling the magnet body; and

a heat-treating step of heat-treating the pickled magnet body in an oxidizing atmosphere containing an oxidizing gas.

[50] A method of manufacturing a rare-earth magnet according to claim 49, wherein the heat-treating step is performed subsequent to the

pickling step.

[51] A method of manufacturing a rare-earth magnet according to claim 49 or 50, wherein the magnet body containing an unprocessed part is pickled in the pickling step.